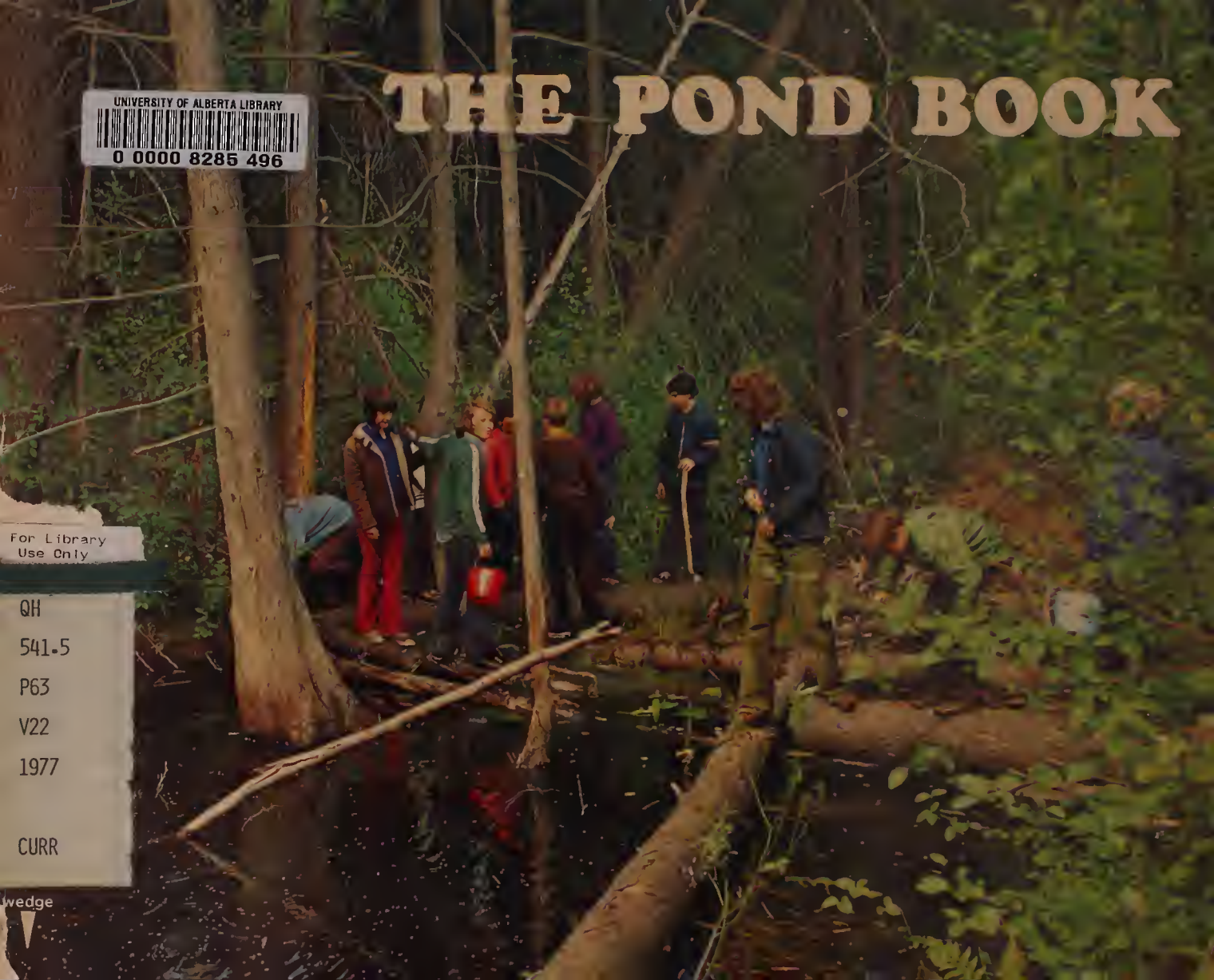

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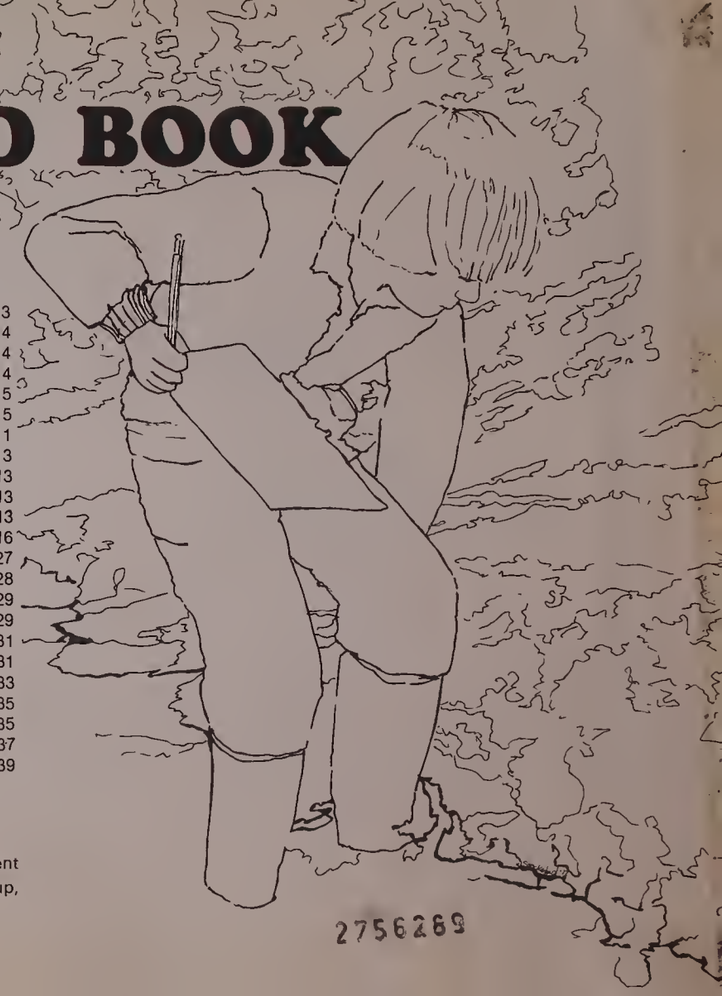

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A Teachers' Guide prepared by the Vancouver Environment Education Project, Western Education Development Group, University of British Columbia, Vancouver

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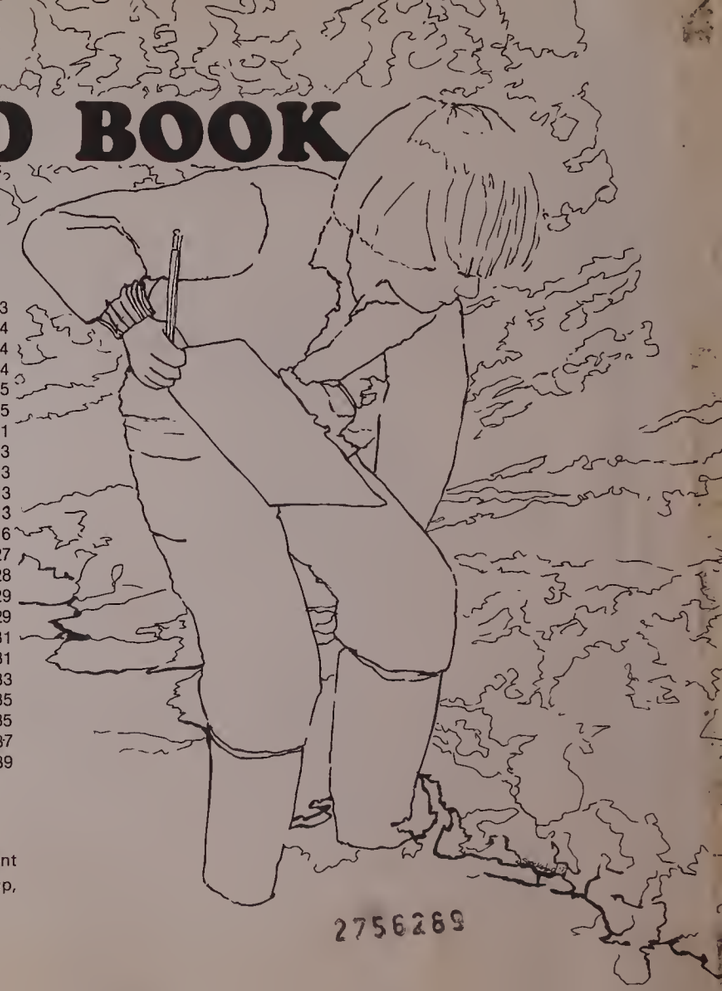

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Introduction

Why Study Ponds?

Ponds are an especially appropriate focus for outdoor education activities. The first and most important reason is simply that kids are naturally attracted to ponds. A pond near an inhabited area receives many visits from children after school, on weekends, and throughout the summer. A second reason is that because of its small size and definite boundaries a pond is an excellent place for kids to learn to deal with fairly difficult environmental concepts such as "ecosystem", "biological community", "food web", etc. A pond is also a focal point for the surrounding habitat as demonstrated by the variety of non-pond organisms which come to drink, feed, or reproduce in and near the pond. Thus, although it is a self contained unit, the pond has easily traceable connections with the countryside around it.

How to Study Ponds — A Philosophical Note

The activities you and your kids carry out and the questions you attempt to answer **should** be the ones which arise out of your students' natural interests. The activities and questions discussed in this guide are only examples, not a series of lessons. **The most important things your kids can learn using a pond are 1) to use their senses,** and 2) **to appreciate the beauty of organisms and the operation of natural communities.** It cannot be overemphasized how important the small amount of time spent at the pond will be toward developing attitudes of conservation, interest in and consideration for living things, and confidence in one's own ability to discover and understand.

FOR YOUR INFORMATION

There is no generally accepted scientific definition of a pond, or of a lake for that matter. A pond is a standing body of water, i.e. not running water such as a stream, creek, or river. A pond is generally also thought of as being shallow; more specifically, shallow enough so plants attached to the bottom can grow over most of its area. However, whether there are attached plants growing all over the bottom depends on the age of the body of water and the water's transparency. A newly dug pond obviously won't be covered with plants. A pond which receives drainage from very rich soil may have such a bloom of microscopic algae in the water itself that plants attached to the bottom are shaded out. So depth is not a reliable criterion, nor is total surface area. Thoreau's famous Walden Pond is actually hundreds of acres in size, and bodies of water less than an acre in area proudly bear the name "lake". It might be an interesting exercise to ask your pupils if they can come up with any definitions that seem to work.

Ponds may be permanent or seasonal. The latter usually dry up in the summer but despite this may possess a surprisingly diverse community of organisms during the wet seasons. A number of pond organisms have ways of surviving in the dry pond bottom, or the capability to move to other wet areas when their pond dries up.

A pond may be "natural", i.e. a low spot in the land which collects seepage water, or "artificial", i.e. constructed by man. Another "natural" but constructed pond which your kids will really enjoy seeing is a beaver pond.

There is no reason a comparison study of ponds could not be undertaken. For example, your class might compare a seasonal with a permanent pond, a small with a large pond, or a young pond (e.g. newly dug farm ponds) with an older one. It is recommended, however, that you select a rich pond first, so that kids can be "turned on" to ponds. A rich pond is one which has lots of aquatic plants growing in and around it, and the water may even be green in color from the growth of algae. Many insects flying around (especially dragonflies and damselflies) are also a sign of a rich pond.

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Most of the activities discussed in this unit deal with the "scientific" aspects of pond study. However, there are lots of other types of activities which can be carried on using the pond, e.g., art activities, poetry and story writing, music, games, problems in mathematics, etc. These activities are just as important as the more scientific ones in developing an understanding and appreciation of the pond, and of our total environment. Suggestions for a number of these activities are included in the unit and teachers working on pond studies will be able to come up with many more.

It goes almost without saying that if this is to be an outdoor education experience, the kids should spend as much time as possible **outdoor**s. We have found it best to make frequent short visits to the pond over an extended period of time, rather than a one-shot field trip lasting most of the day.

How to Get Started

Having decided to make a pond the focal point for an outdoor education experience you are then faced with the question of choosing an appropriate site. A major consideration, of course, is distance from the school, but there are other considerations as well. For example, it is better to choose a fairly small pond rather than a large one, especially if detailed study is planned. If possible, a pond rich in animal as well as plant life should be chosen and a pond with room to work on the bank well away from the edge is preferable.

So, how do you find the perfect pond? The simplest way is just to ask the kids for suggestions, and then you can check them out at your leisure. In the unlikely event no one in your class knows of a pond, and you have none in mind, you can ask local naturalists, farmers, Scout leaders, the Fish and Wildlife Branch Conservation Officers, etc. Somebody will know of just the pond for your group!

Preparation and the First Visit to a Pond

Besides transportation arrangements and obtaining necessary permissions from landowners and parents, you need only ensure that your kids are dressed in old but warm clothing, and have as nearly waterproof footwear as possible. If a whole class is going at once, try to invite two or three parents to help you.

The first visit to the pond **must** be a time of exploration, a true adventure, and should **not** involve a list of projects to be completed in the allotted time. It is recommended that no collecting or recording equipment be taken on this first trip. All you need say to the children is that you are all going to take a look at a pond, just to see what is interesting about a pond. You should, however, stress to the kids that a pond (and especially its shoreline) is more fragile than it looks, and that even too many footsteps around the edge will destroy living plants and animals. It might even be a good idea to park some distance from the pond, and let the kids run off some of their excess energy before they reach the pond.

Sensing the Pond Environment!

Spend some time seeing how many different smells the kids can find in and around the pond (crush a leaf, smell a handful of earth, etc). Have everyone be quiet for a minute and see how many sounds they can hear. How many colors can they see? What's the tiniest living plant or animal they can find? Have them take a minute to look for the softest thing they can find. How many different animals can they find? Don't collect them, just look!

This first visit should be of fairly short duration, say less than an hour. When you get back to the school, any questions that the kids bring up can be discussed in detail.

To summarize the activity, have the class help you draw a general map of the pond on the blackboard. Include as many details as the kids can remember. There will probably be disagreements about some of the details, and the kids will want to make another visit to check. Another follow-up activity after the first visit is to ask the kids to paint or draw a colored picture of the pond, and its shore. What colors do they remember as predominating? Suggest the children bring the drawings with them on the next visit to the pond, and make any changes they wish.

After the first visit, the teacher can initiate discussion about "what would we like to know about the pond to really understand it?" The responses will probably include some or all of the following:

a) How big is the pond? e.g. circumference, depth, area, how much water?
b) How did the pond get there? Who built it, etc.?
c) How old is the pond?
d) What lives in the pond? How many different kinds of things; what do pond animals eat; where do they live in the pond; how did the living things get into the pond?
e) Is the water safe for drinking? Is it safe for swimming? Is it polluted?

These and other responses can provide student-originated avenues for beginning the pond study. Many other questions will come up naturally as your class works on the pond.

Once you and your class have decided **what** you would like to know about the pond, you should discuss **how** to obtain the needed information. Some information can be obtained through direct measurement or observation (a, d and e), but categories b and c are matters for speculation, and everyone can contribute to this sort of discussion. Ask for initial guesses about how big or deep the pond is, how it can be measured, and about what kinds of animals live there. The pupils will have already seen a few. In any case, the children should be asked what sort of equipment they think will be needed in the study, and how it should be used. A suggested equipment list is included here, but let the kids come up with as many items as possible on their own.

Equipment

The following equipment is all you need to do a thorough study of a pond. Get everyone in the class involved in gathering or making it!

1. Some glass jars or plastic containers, preferably fairly large, with lids.
2. Several hand magnifying lenses.
3. Several dip nets. Can be made from fairly coarse netting or old nylon stockings (the old fashioned non-stretch type are best), some coat hanger wire, and a stick or pole.
4. A plankton net for microscopic organisms living in the open water can easily be made from old nylons, with a small plastic vial tied at the end. This net can be towed through the water on a string, or mounted on a pole and used like a dip net.
5. Some small vials with caps.
6. Plastic bags.
7. Measuring tape or twine marked off in metres.
8. Graduated stake or metrestick.
9. Notebook or clipboard with paper.
10. Thermometer.

Other pieces of equipment which would come in handy but are not absolutely necessary are the following:

11. Microscopes, glass slides and coverslips.
12. Rain gauge (easily made with a large graduated cylinder and funnel).
13. Hip waders.
14. Small inflatable rubber boat with oars. Inflatable air mattresses are useful too!
15. Aquarium with cover.
16. Small mammal traps.
17. Preservative solutions — formalin or alcohol. Handle both with care.
18. Various water testing materials, e.g. litmus paper for testing pH, oxygen testing kit. The oxygen kit is expensive, and it contains acid, so be cautious.

How Big is the Pond?

Circumference:

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Another method involves the use of a trundle wheel.* A bell can be attached to the wheel and the wheel is rolled around the perimeter of the pond, ringing the bell each time the wheel makes one revolution. If the wheel has been designed to have a circumference of one metre, then the number of rings equals the distance in metres. A variation on this would be to push a bicycle around the pond and have someone count the number of times a chalk mark on the wheel reaches the top. Then you can multiply this number by the circumference of the bicycle wheel.

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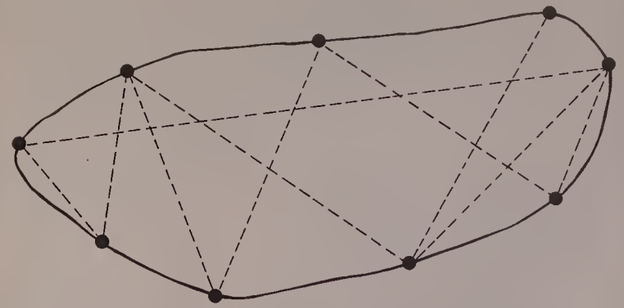
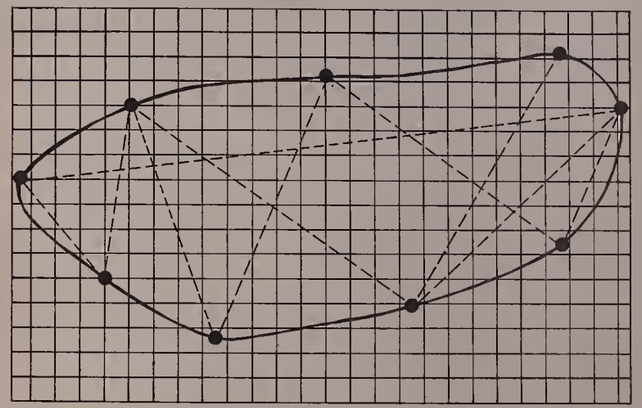




Area

A very rough calculation of the area covered by a pond can be made by dividing the circumference of the pond by 6.28 (since circumference equals $2\pi r$) to give the radius:

$$r \text{ (radius)} = \frac{\text{circumference}}{2\pi} = \frac{\text{circumference}}{6.28}$$

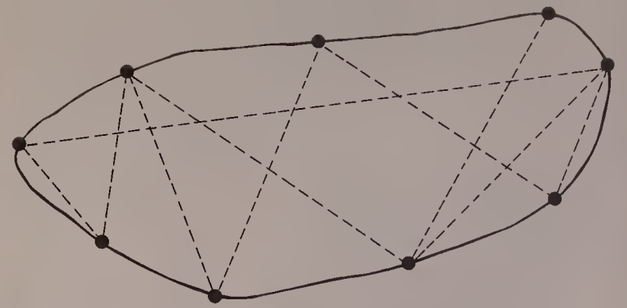
Then use the value for the radius to calculate the area of the pond, assuming that it is a circle: $A = \pi r^2$.

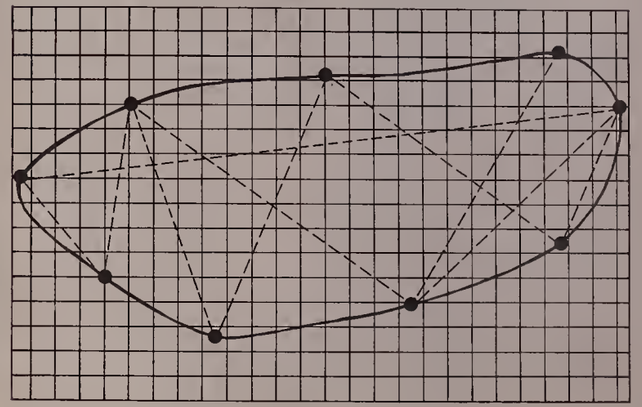
Another and perhaps better way to get the area of the pond is to make a **scale diagram** of the pond and determine the area from this. First put about 6–10 stakes at selected points all around the edge of the pond. Then measure the distance between each stake and all the others using a measuring tape and hip waders or a boat! With these measurements, make a rough sketch of the pond on graph paper. Then compare the sketch with the actual pond and fill in the irregularities along the shoreline.

From the completed scale diagram, you can determine the area of the pond very accurately by counting the number of squares and parts of squares that fall within the diagram's outline. Multiply by the scale for one square of graph paper. This is easy if you use graph paper with large squares and let each square equal one square metre. This scale diagram of the pond will also come in very handy for plotting the precise location of various items of interest in the pond, e.g. a group of water plants or a clutch of frog eggs.

Now that the kids have some idea how far it is across the pond, ask them how long they think it would take a battery-powered boat to make the crossing. Then launch a boat and find out! Try sailing folded paper boats or model sailboats across. Make miniature rafts out of string and little sticks you find around the pond. Let the kids prove to themselves that metal floats by making sardine can sailboats! Rig a mast from a piece of dowel or a pencil lashed in place, and stick a piece of paper over the mast for a sail.

See if waves generated on one side of the pond cross the pond faster than a model boat can. Is the wave lapping on the opposite shore caused by water that has moved all the way across the pond, or is it caused by "wave energy" that





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has been passed along through the water? The kids can prove it is not the former, just by putting one of their boats in the pond, generating a wave and noting that the boat "rides" over it, rather than being carried all the way across the pond. What happens when waves started on opposite sides of the pond meet in the middle?

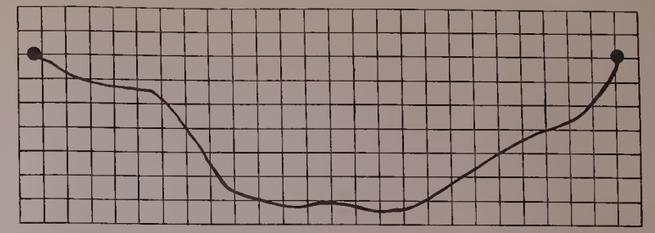
Depth:

The **depth** of the pond can most easily be measured by one child wearing **hip waders,** walking across the pond taking depth measurements with a metrestick. A word of caution here though: **chest waders** should be avoided because if a child falls, they quickly fill with water, making it impossible to stand up again. This is not only frustrating, but dangerous and could lead to a drowning, even in shallow water. Obviously, even hip waders cannot be used where the water looks deep, and they should only be used with great caution, if at all, where the bottom sediment of the pond is soft. In fact, it is a very good idea to have the measurer carry one end of a stout rope as he makes his way across the pond.

If the pond is too deep, or the bottom too soft for safe walking, then a small inflatable rubber boat comes in handy or use a raft constructed on the site. Don't forget to use life jackets. A large number of accurate depth soundings can be made easily by using a weighted line marked off in centimetres.

If the pond is unsuitable for walking and no boat is available, a third method is possible. Attach a weighted plumb line to the middle of a long piece of string. The plumb line should be marked off by colored tape or alternate sections of the line painted different colors. Have two children take the ends of the long line to opposite sides of the pond, and gradually lower the plumb line until it reaches bottom. Then move the plumb line nearer to one side of the pond and repeat. If the long line is graduated in metres, then a very accurate depth profile of the pond can be obtained.

By whatever means the depth measurements are made, they can be used to make a **cross-sectional scale diagram** of the pond, once again using graph paper. The approximate depth locations of various plants or other features in the pond can then be plotted on the diagram.



An exciting art activity is to make a full scale painting of a part of the pond's cross-section. The painting can be made on a 1 by 2 metre piece of fiberboard or plywood.

Volume:

Having made all the measurements necessary, it would be a shame not to attempt to calculate the volume of water in the pond. This cannot be done with absolute accuracy, but it is fun to try different methods and compare the results.

a) If we assume that the pond has the shape of a squashed cylinder, then we can use the formula: Volume $= \pi r^2 h$
where h is the **average** depth and r is the radius.

b) If we assume the pond is shaped like a cone, we can calculate:
where h is the **greatest** depth: Volume $= \frac{1}{3} \pi r^2 h$

c) And if we think that the pond has the shape of a hemisphere:
Volume $= \frac{2}{3} \pi r^3$

The volume is recorded in units of cubic metres. This can easily be converted to litres; 1 cubic metre = 1,000 litres. How many glasses of water could you get from the pond? If you have a pump which can pump 100 litres per minute, how long would it take to pump the pond dry?

Now it might be interesting to calculate the total **weight** of water in the pond. But first, be sure to have the kids guess how many kilograms of water there are in the pond. Most people underestimate the weight of a given volume of water;

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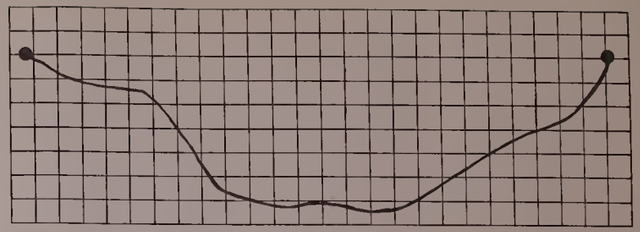

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the water in an average sized aquarium of 45 litres capacity weighs 45 kilograms. To calculate the weight from the volume of water in the pond, use this relationship:

1 litre of water weighs 1 kilogram

How Did the Pond Get There?

The question of the pond's origin is actually two questions: how has the basin of the pond formed, and where did the water come from to fill the depression? The first question is difficult to answer precisely, except in the case of obviously man-made ponds, but is an interesting question for your class to discuss. All we can say for sure is that pond basins are lower than the immediate surrounding landscape, or are found on flat terraces in rolling terrain, i.e. any place water can collect.

If the pond is man-made, try to guess why it was constructed. For example, are there livestock around which might need drinking water, did someone want a "fishing hole", a place to go swimming, a home water supply, or did someone just like ponds! One reason many farmers build ponds is to have a ready supply of water in case of a fire.

An excellent activity is to ask the pupils to write a one page story while they are actually at the pond. A good topic here might be "The Birth of the Pond". Spread the kids out as much as possible to give everyone a little thoughtful privacy.

Now, where is the water coming from to fill the pond? Can you see any inlet streams? Suggest that the kids hunt for evidence of springs supplying water underneath the surface of the pond.

To check if rainfall alone can keep the pond full, you can put out large wide-mouthed jars of water with the water level marked on the side. Put a few of these around the pond, and check them every week or so to see if there is a net gain or loss of water as time passes. Also place a metrestick (any stick marked in centimetres will do) in the pond, and check the pond level fluctuations during this period. Compare the fluctuations of the pond water level with the water level fluctuations in the jars. The jars will illustrate the process of evaporation which can then be related to the pond. And if you have found underwater springs or an inlet stream, but no obvious outlet, the importance of evaporation becomes evident!

To get an even more precise idea of the amount of evaporation, put a cover about ten centimetres above one of the jars which you have placed around the pond. This prevents rainwater from confusing the issue, but allows evaporation to take place.

If you want to measure the exact amount of rainwater entering the pond, put out a raingauge and measure the rainfall for a week. Then measure the surface area of the raingauge and multiply by the appropriate value (since you know the surface area of the pond) to get the total volume of rain which fell on the surface of the pond. This can then be compared with the total volume of water already in the pond, which you previously calculated. How many weeks would it have to rain to fill the pond assuming no loss by evaporation?

Since the class is working with jars filled with water, why not get some other glass containers, of various shapes and

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The source of the water that fills the pond may be rain-water, seepage (springs), an inlet stream, or any combination of these. Most permanent ponds are spring or stream fed. The springs that feed a permanent pond are often hidden under the pond bottom, and hence are difficult to detect, although the aquatic vegetation growing near them will often be a different species from the rest of the pond plants. In addition, the temperature of the water near a spring tends to be cooler than the rest of the pond in summer and warmer in winter. The difference in temperature, along with the chemical content of spring water, accounts for the plant species differences near springs.

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sizes, and put together a "Pond Jug Band". Wide-mouthed containers filled with different amounts of water can be tapped with a stick. Narrow-mouthed containers (pop bottles, jugs) can be filled to various levels, and the mouth of the bottle blown across to produce an assortment of sounds. All these instruments can be "tuned" by experimenting with water levels.

How Old is the Pond?

Although one cannot accurately determine the age of a pond, it is possible to divide ponds into broad categories according to age. The very oldest ponds or lakes in B.C. cannot be more than 10,000 years old, since that was the time of the last glaciation. Most ponds are **very much** younger than this. The average age for ponds is probably only a few hundred years, because they tend to fill in with vegetation quickly. Try having everybody in the class search for evidence of the pond's age. One of the best ways to determine a pond's relative age is to compare it with another pond whose age you know, e.g. a man-made pond.

While the class is at the pond, distribute painting or drawing materials and ask the kids to show what they think the pond and the surrounding area will look like in 50 years. Then ask them to draw their prediction of the pond's apppearance in 200 years.

What Lives in the Pond?

This general question is one of the first ones your class will want to answer. Although measuring the size of the pond and guessing its origin and age are interesting activities, you will find these activities are quickly forgotten if someone finds a frog, a fish, or an interesting insect. Kids are naturally attracted to other living things. If you as a teacher do nothing more than give your pupils the chance to find, watch, touch and just generally get to know living plants and animals in their natural environment, you will be a resounding success.

In the discussion following the first visit to the pond, besides the general question of what lives there, someone probably will have raised the specific question of **how many** different kinds of living things will be found at the pond. Either question can form the basis for another visit to the pond to observe or collect and identify the organisms. Have everyone guess how many different kinds of things will be found, and then go to the pond to see whose guess was closest. If possible, also get the kids to come up with some rules about collecting, which hopefully will include a) not destroying things as one collects (e.g. ripping up plants) and b) after all collections have been compared, putting back everything collected with the possible exception of one specimen of each type to be preserved for later study.

Collecting:

Collecting most kinds of organisms is simply a matter of using dip nets, plankton nets, or bare hands! If there are fish in the pond, you might want to try a net made from 2 poles and a length of netting. To catch tadpoles and salamanders, a small live trap can be constructed from a large plastic bleach bottle. Cut the large end of the bottle off, staple or wire a funnel made from hardware cloth into this opening, and put the trap on the bottom of the pond. Check the trap daily. Just take the bottle cap off and pour out the catch.

If you are lucky enough to capture a frog, put him on the ground and measure the distance he can jump. Can the kids jump that far from a standing start? Have the children crouch down like frogs with legs bent and try jumping again. Can they go any further? Try having a "frog hop" race around the pond!

Using Microscopes:

It's definitely a good idea to bring microscopes along when visiting the pond. Bring a folding table too, to set the microscopes on. Make sure everyone finds out how to adjust the mirror to get enough light and how to focus the microscopes. Also have the kids clean the microscope lenses. It is quite a thrill the first few times one really sees the "life in a drop of water" through a properly functioning microscope. Hand magnifying lenses are also very useful, e.g. for observing the details of the structure of a mayfly larva's gills or a developing frog egg.

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FOR YOUR INFORMATION

A. The youngest ponds are almost always going to be man-made (though you might be lucky and find a newly formed pond caused by a rock slide or fallen trees blocking a stream). Such young ponds are characterized by clear water (i.e. low plankton densities) and few rooted aquatic plants growing on the bottom. The bottom may even be sandy.

B. Ponds of medium age tend to be more shallow and they have aquatic plants growing in the water around the edge of the pond. The water may be green due to blooms of microscopic algae, especially in the warmer months.

C. The oldest ponds are very shallow and aquatic plants grow all over the bottom. The vegetation is in fact filling in the pond from the bottom up, and the edges inward. Large areas that were once under water all the time are now only periodically inundated and the community of organisms characteristic of marshes takes over these areas. Eventually, the remains of dead plants fill and raise these areas until they are never covered with water.

At this point, another group of organisms may invade — the plants and animals that make up the bog community. Some of the members of this group — species of *Sphagnum* moss — are very typical in old pond and lake situations and these mosses rapidly fill up the remaining open water. It should be noted that this sequence of events in pond succession is only a generalization, and not all ponds undergo succession in exactly this way.

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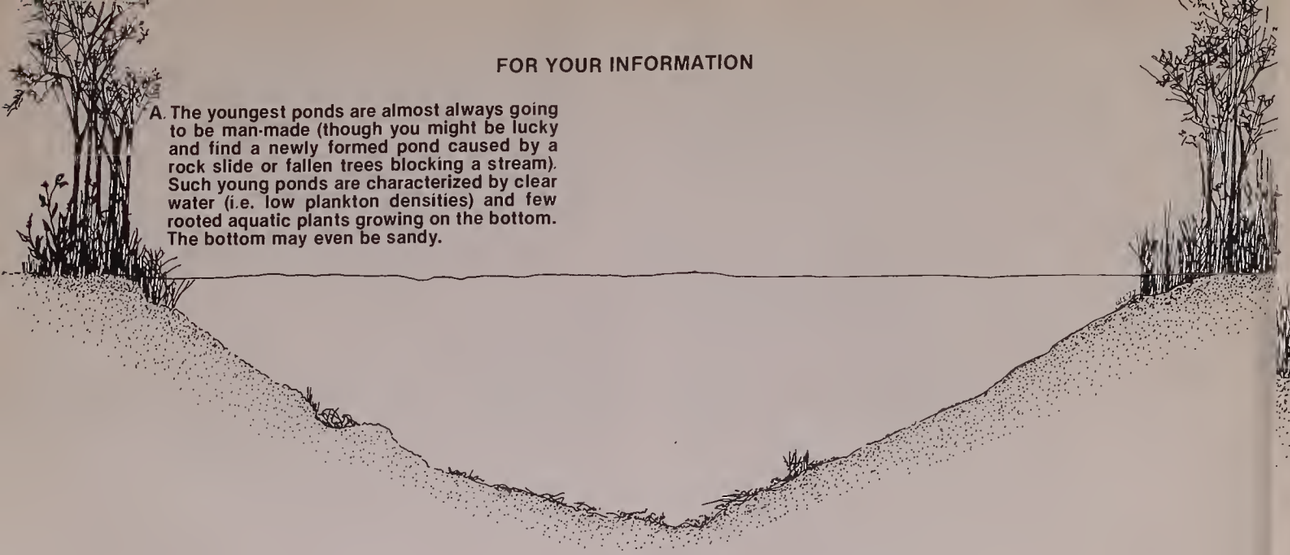

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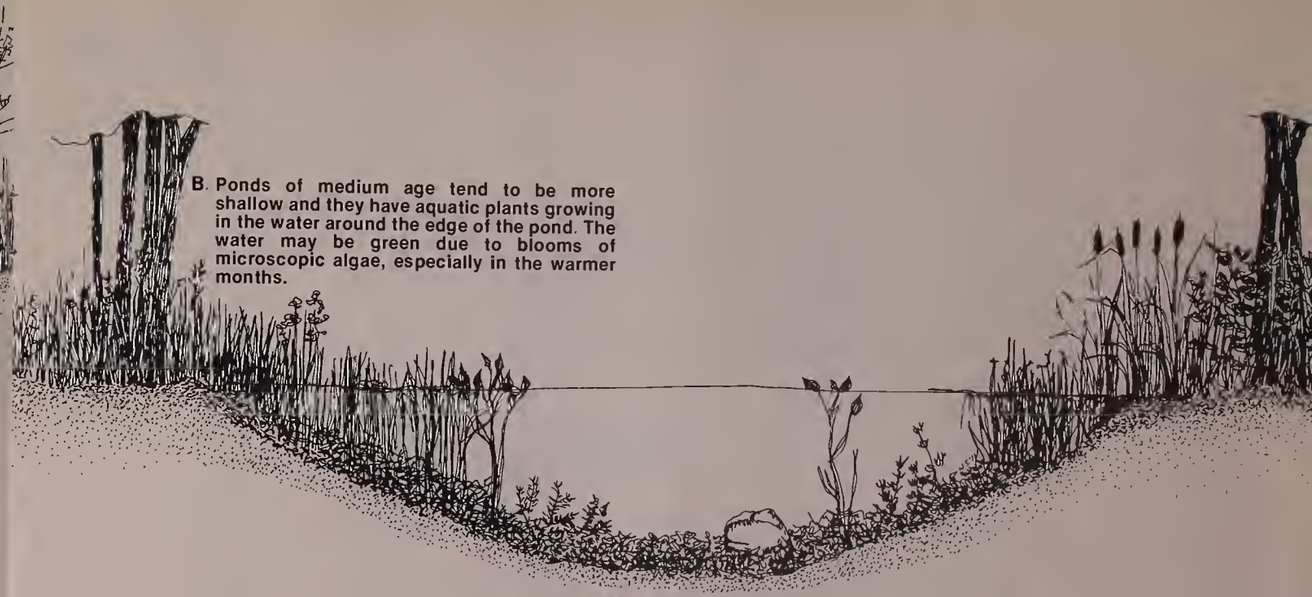

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Identification:

Identification of collected organisms may be made with any of a number of general or detailed keys. Many kids are interested in what the name of something is. However, it would be better not to bring identification manuals along on the first collecting trip, but rather to encourage your pupils to use their eyes (and some pencils and paper) to determine and draw or otherwise record the outstanding features of the different plants and animals they find. Then they can give names to some organisms themselves. This can be an important lesson about how scientists name living things. A name is coined, based on the prominent characteristics of an organism, and a group of scientists agree to use those words as a name to refer to that particular species. Once the class has carefully named the organisms, then the teacher can raise the question of how people **outside** the class will know what is meant by a certain name. And from here it is an easy step to use the identification keys. Knowing the official name for a plant or animal will mean much more to children, because they will begin to understand how taxonomy is done and why it is so important.

Here is a game which provides another way to demonstrate how important it is to choose words carefully when we are describing an object, and it is fun too! Have everybody sit in a circle (or divide up the class into 3 – 4 circles), and hand one of the children in the circle a pond object: a leaf, some frog eggs, an insect larva in a little jar, etc., without the others seeing. The first person looks at the object, secretly, and says **one descriptive word** which applies to the object. Then the object is passed on to the next person, and so on. Tell the children not to reveal the name of the object. Have someone record the words as the object is passed around. After a few rounds, discuss with the group how many words are really needed to describe objects uniquely, and go back over the list of words to show how the possibilities "narrowed down" as more words were added. How many words does it take for the object to be identified by those who haven't seen it?

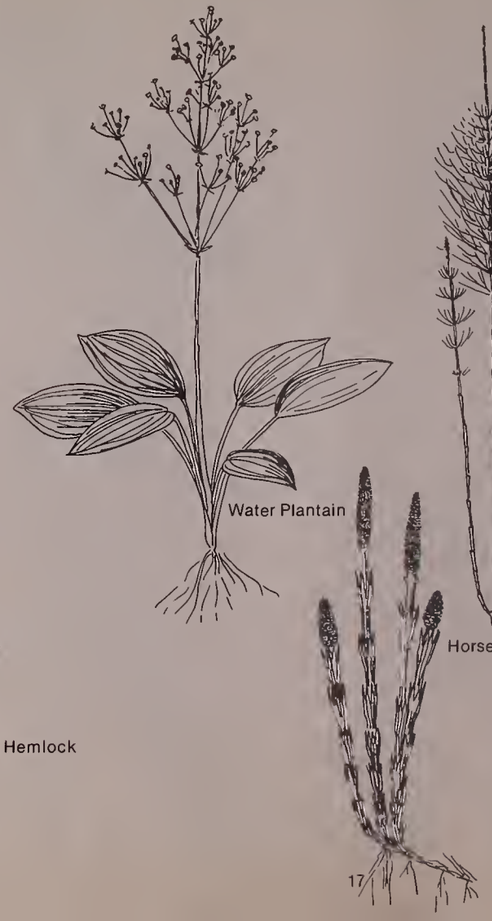
An interesting activity which can be suggested to the class at this point is to construct a key for identifying the organisms inhabiting the pond, using both class selected names and the official names.

16

SHORE PLANTS

After Jeanne R. Janish

EMERGENT PLANTS



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SHORE PLANTS

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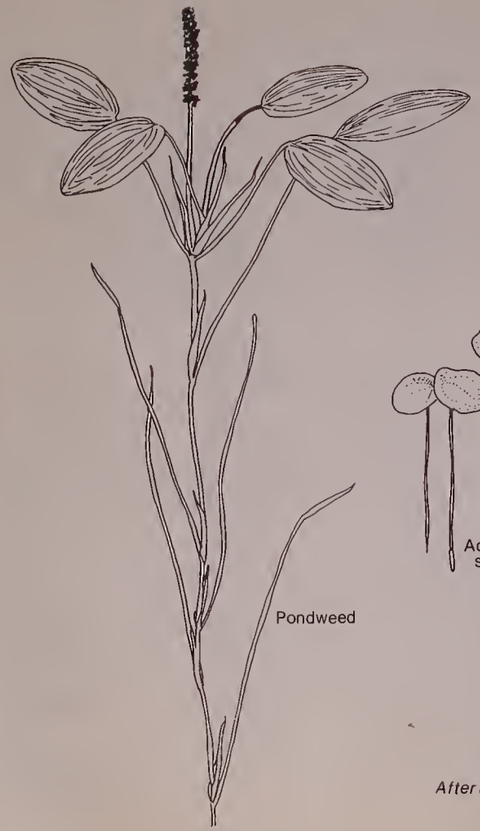
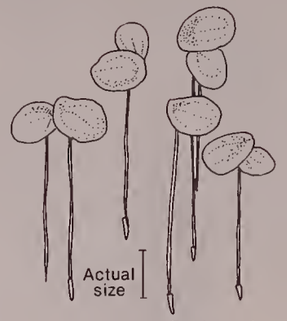
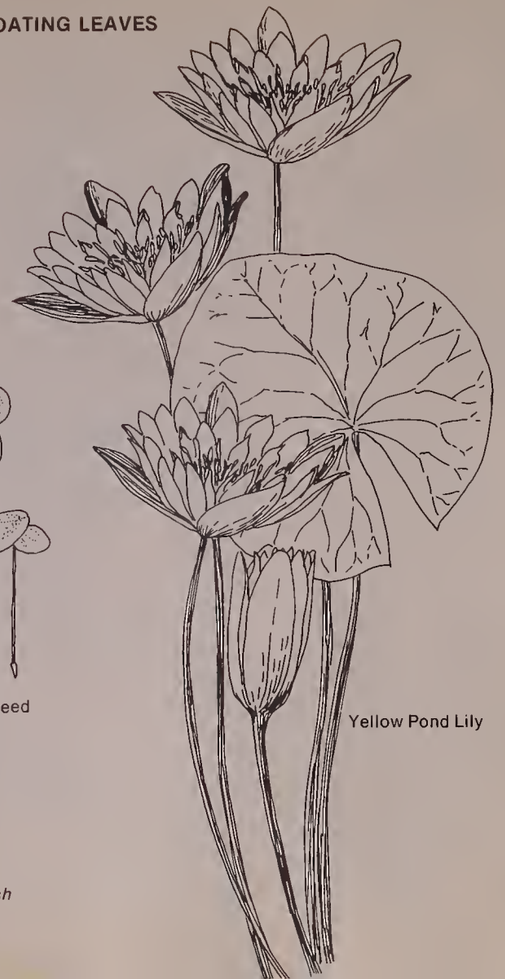
FLOATING PLANTS OR FLOATING LEAVES



Pondweed



Duckweed

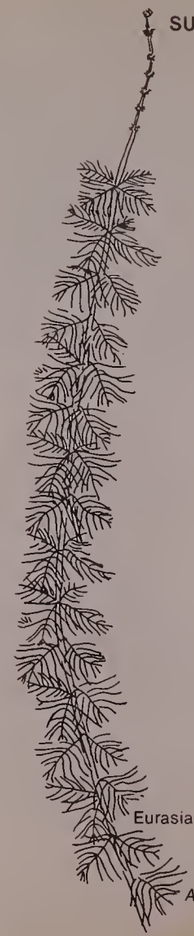


Yellow Pond Lily

After Jeanne R. Janish

SUBMERGED PLANTS

Water Weed

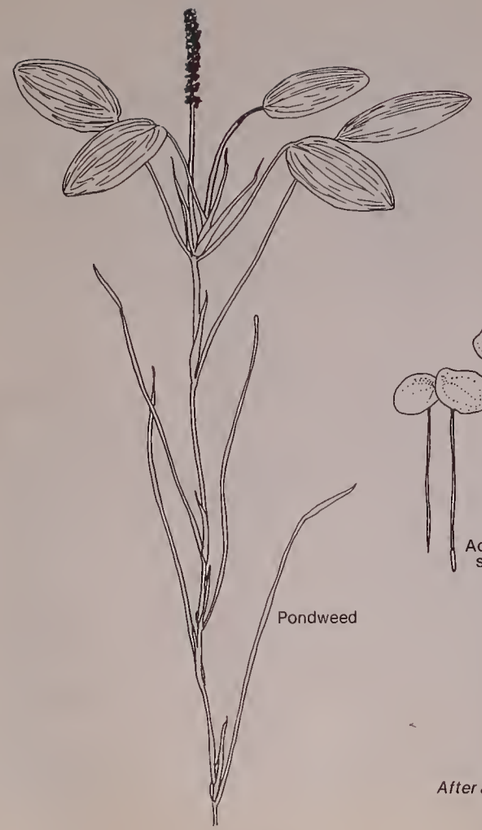


Eurasian Water Milfoil

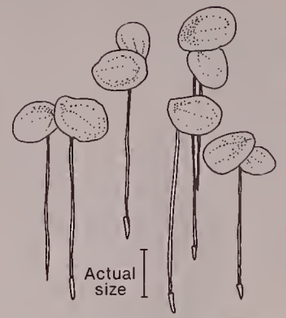
After Jeanne R. Janish

Other Species of Water Milfoils

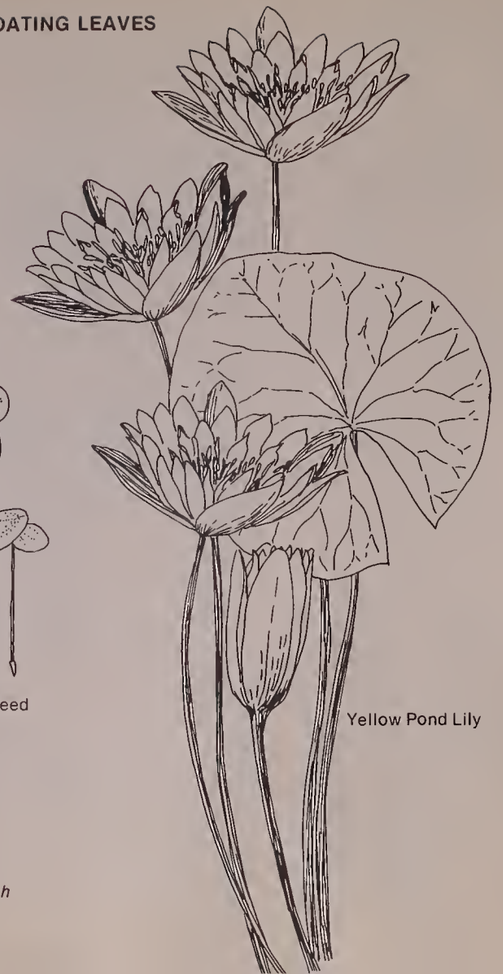
FLOATING PLANTS OR FLOATING LEAVES



Pondweed



Duckweed



Yellow Pond Lily

After Jeanne R. Janish

SUBMERGED PLANTS

Water Weed

Eurasian Water Milfoil

After Jeanne R. Janish

Other Species of Water Milfoils

FOR YOUR INFORMATION

Microscopic green plants are called *algae* and are either unicellular, colonial, or filamentous, i.e. composed of single cells, cells in groups, or cells attached to each other end to end in filaments. Algae have no roots, stems, or leaves. Algae can be found floating in open water, in the mud on the pond bottom, or attached to the stems and leaves of larger rooted aquatic plants. There are very many different types of algae, so only a few examples can be illustrated here. The most common types are:

- **Green Algae** - may be unicellular, colonial, or filamentous; some are motile, swimming by means of flagella.
- **Desmids** - usually unicellular but sometimes filamentous; the two halves of a cell are usually symmetrical copies of each other; greenish in color. Desmids are actually Green Algae, but so specialized that we set them off separately.
- **Diatoms** - usually unicellular but occasionally colonial or filamentous; have a unique silica "shell"; usually yellow brown in color.
- **Blue-Green Algae** - unicellular, colonial, or filamentous; primitive algae related to bacteria but quite common in ponds.

Rooted aquatic plants are called *macrophytes* and include some types which are always submerged, some whose leaves float on the surface, and some which emerge from the water. Some familiar examples are various pondweeds, cattails, and water lilies. Microscopic animals may live in the open water, on the bottom of the pond, or attached to the stems of aquatic plants. Microscopic animals may be unicellular, e.g. protozoans; colonial or multicellular, and most are motile. The multicellular microscopic animals include rotifers, tiny crustaceans such as cladocerans and copepods, and tiny water mites which are often colored red and are close relatives of spiders.

The most abundant group of larger animals is the insects. Some insects only live in the pond during their larval or nymph stages, e.g. dragonflies, caddisflies, midges, and mayflies, while others spend their whole lives in or on the water, e.g. diving beetles, water striders, water boatmen - see illustrations on pages 21 to 25.

In the last few years, people in British Columbia have heard a lot about one species of freshwater macrophyte, *Myriophyllum spicatum,* or Eurasian Water Milfoil. The reason is that this familiar bushy aquarium plant has invaded the Okanagan Lake system and, by growing profusely in swimming and marina areas, is threatening the tourism industry of the Okanagan region. No one knows how this plant got into the Okanagan lakes, but it may have been introduced when someone dumped the contents of his aquarium. Unfortunately, this foreign species can grow several centimetres per day in warm weather. Another unusual characteristic of these plants is that, although they can flower and produce seeds, they usually reproduce by fragmentation, i.e. small bits of vegetation break off and float away. The fragments grow in length while floating, and eventually they begin to form roots and sink.

This plant is able to invade new habitats easily, partly because: it reproduces mainly by fragmentation; it is adapted to grow in nutrient-poor conditions, in standing or flowing waters, and on almost any type of bottom material; it can grow in a wide range of water depths; it can tolerate some drying; it can survive long trips from place to place on boats and trailers or in the feathers of birds. Like many other aquatic plants, Eurasian Water Milfoil is stimulated by nutrients from sewage or farmland.

Several control measures have been attempted in North America. Success varies depending on specific local circumstances. One common measure has been to cut and remove the shoots with harvesting machines on boats. Unfortunately, the rooted basal portions quickly regrow, and more fragments may be released unless careful fragment control measures accompany harvesting operations.

Several native species of Milfoil occur in British Columbia. The introduced Eurasian Water Milfoil occurs primarily in the Okanagan Valley, but can spread to other areas too. No aquatic plants should be carried from one location to another.

GREEN ALGAE*

Euglena
(Unicellular, Motile)

Pediastrum
(Colonial)

Spirogyra *Zygnema*
(Filamentous)

Eudorina
(Colonial, Motile)

Scenedesmus
(Colonial)

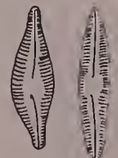
Desmids*

Cosmarium

Micrasterias

Closterium

DIATOMS*



Navicula

Stephanodiscus

Diatoma

Cymbella

* As viewed under the microscope

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(Colonial)

Desmids*

Cosmarium

Micrasterias

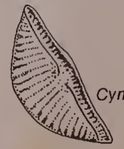
Closterium

DIATOMS*

Navicula

Stephanodiscus

Diatoma



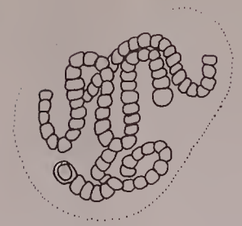
Cymbella

* As viewed under the microscope

BLUE-GREEN ALGAE *

Oscillatoria

Rivularia



Nostoc

Gomphosphaeria

Microcystis

PROTOZOA*

Vorticella

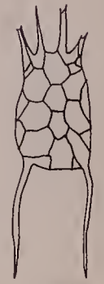
Stentor

Paramecium

ROTIFERS*

Polyarthra

Rotaria



Keratella

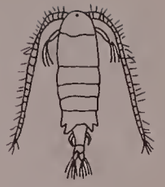
* As viewed under the microscope

MICROCRUSTACEA*

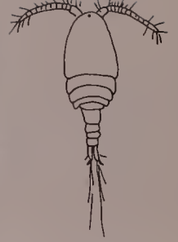
Ostracod
(Cypridopsis)

Cladoceran
(Chydorus)

Cladoceran
(Daphnia)



Copepod
(Diaptomus)



Copepod
(Cyclops)

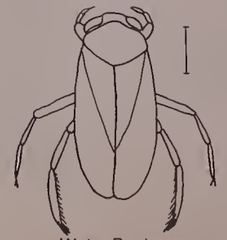
Copepod
(Canthocamptus)

* As viewed under the microscope

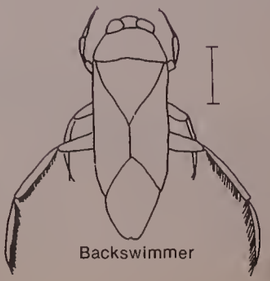
INSECTS

Whirligig Beetle

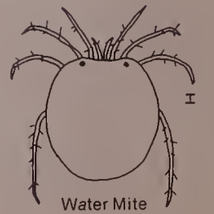
Predaceous Diving Beetle



Water Boatman



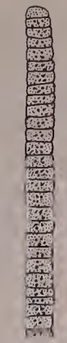
Backswimmer



Water Mite

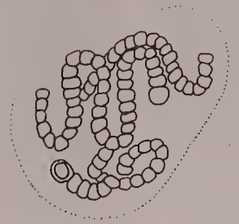
⊢⊣ Actual size

BLUE-GREEN ALGAE *



Oscillatoria

Rivularia



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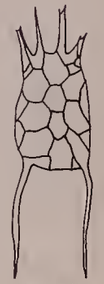

Keratella

* As viewed under the microscope

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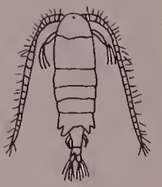
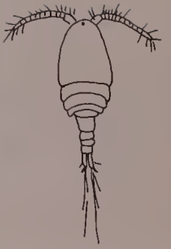


Copepod
(Diaptomus)

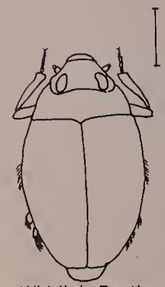


Copepod
(Cyclops)

Copepod
(Canthocamptus)

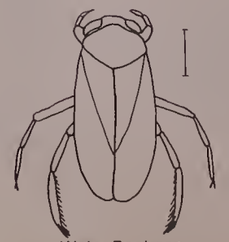
* As viewed under the microscope

INSECTS

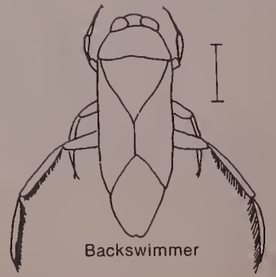


Whirligig Beetle

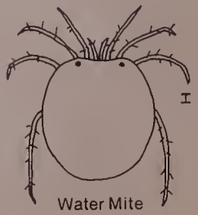
Predaceous Diving Beetle



Water Boatman



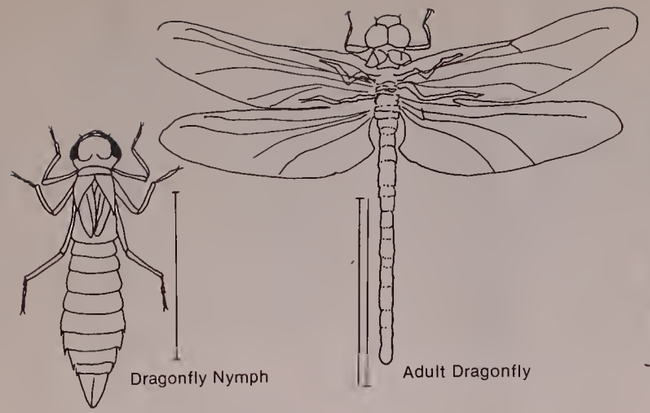
Backswimmer

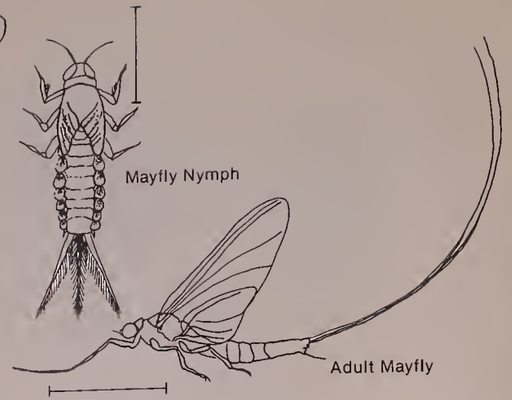


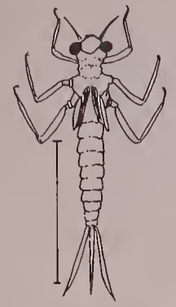
Water Mite

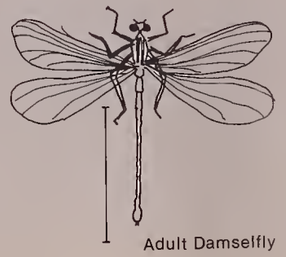
⊢ Actual size

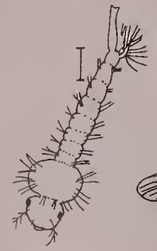
INSECTS

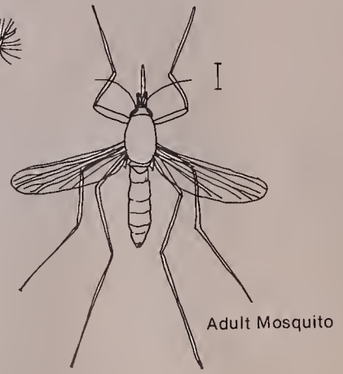




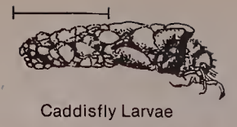


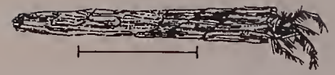


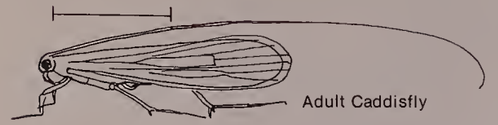




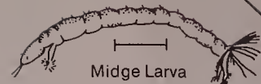
Actual size

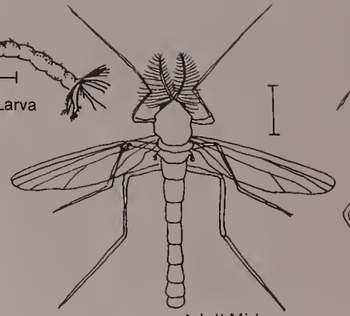


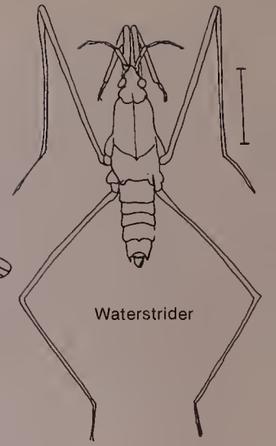




INSECTS







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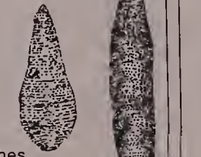
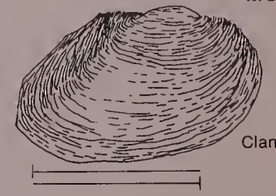
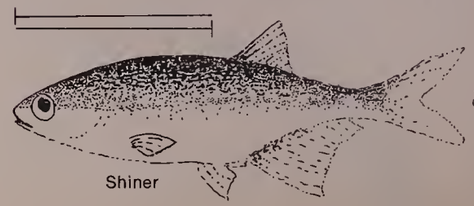
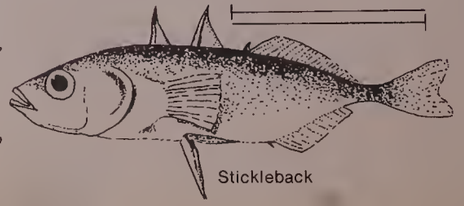


MOLLUSKS



FISH





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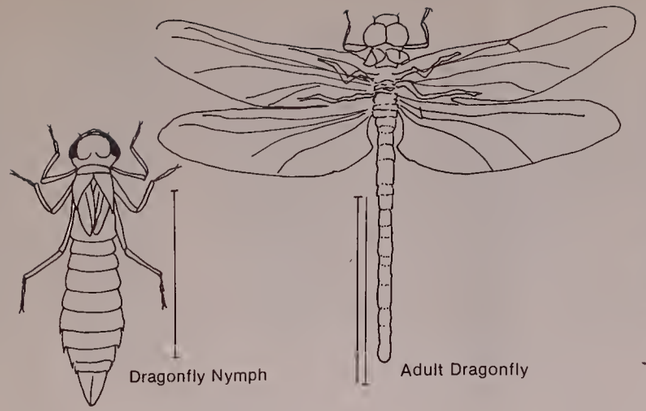

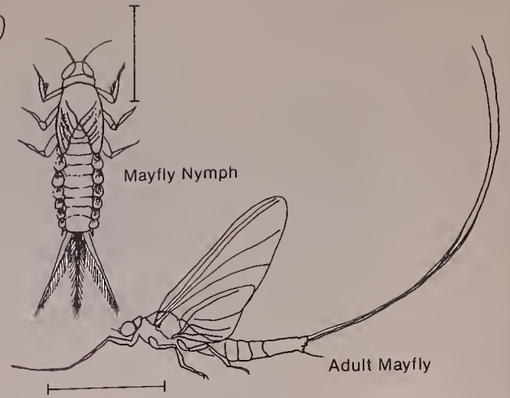

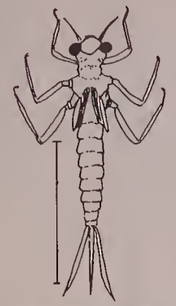

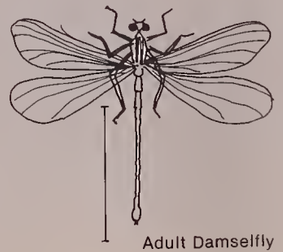

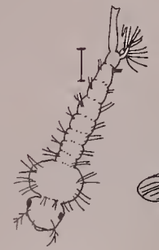

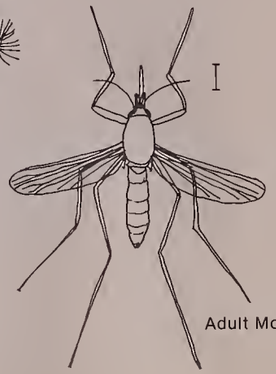

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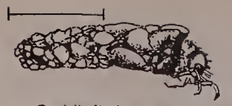

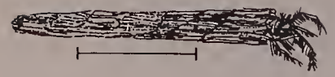

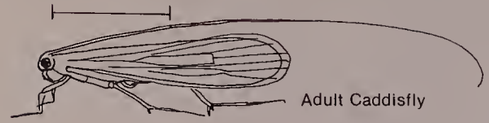

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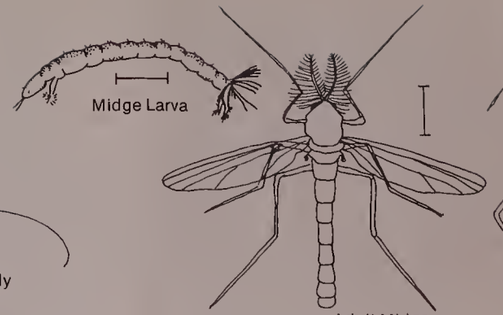

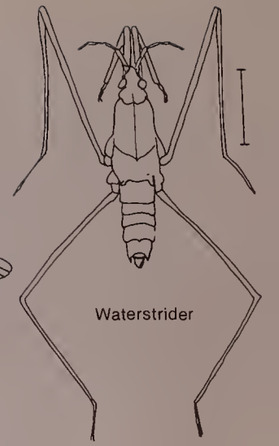

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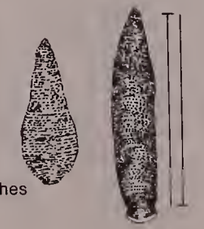

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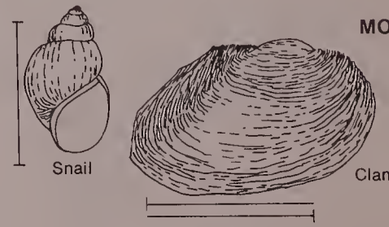

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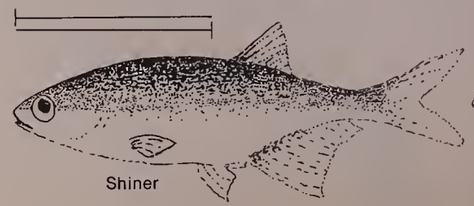

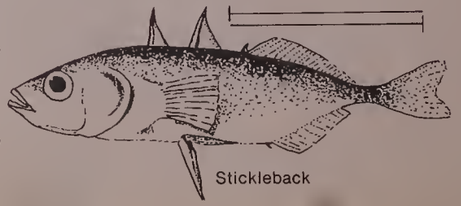

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Where Pond Animals Live

A question which will come up sooner or later is where in the pond do the different organisms live. This may require another visit to the pond to focus on this question. In any case, the scale diagrams of the pond's surface and its cross section will come in very handy to pinpoint the location of each type of plant and animal. If possible, make collections or observations over a period of time, and compare the locations of the different species each time. Ask the kids to examine the data to see how many different habitats are found in the pond. e.g. the shallow weed zone, the open mud zone, etc.

To sample the organisms living in the open water, throw the plankton net out to the middle and pull it back to shore with a string. Or reach out from the shore with a fine net, perhaps tied to a long pole, and swish the net back and forth in the water. Another possibility is to dip buckets of water out of the pond and pour the water through fine netting or nylon stocking material, and even finely woven cloth such as a handkerchief.

Sampling the bottom sediment can be done by scooping up the mud or sand with a jar or bucket, or dragging a net through the top few centimetres of bottom material. Numerous tiny organisms can be easily separated from bottom sand by shaking some of the wet sand in water, letting the sand settle for just a few seconds, and decanting the overlying water which contains the organisms. For muddy sediments, it is best to let the organisms separate themselves. Place a jar with your mud and water sample where it gets light from one direction, such as on a windowsill (not too hot!), and wait for several hours. Many pond organisms will congregate on the lighted side where they can be sucked out with a large eyedropper. This method also works well for separating pond animals from a tangle of pond weeds.

Another way to sample the pond bottom is to take cores. If possible, use a piece of glass tubing or transparent rigid plastic tubing. The tubing doesn't have to be more than 15 cm long, and should be between one and three cm in diameter. The walls of the tubing should be thin. To take a core sample, push the tubing carefully into the sediment five or ten cm , then close the opening at the top with your thumb or a cork, and withdraw the core and cork it at the bottom. If transparent tubing is used, the children can observe the layering of the sediments in the pond bottom. By carefully letting out the sediment a couple of centimetres at a time, and separating the animals from each layer using one of the above methods, the pupils can study the **vertical distribution** of the different kinds of organisms. Most will be found in the uppermost centimetre. Why might this be so?

An interesting exercise is to take a very small bit of pond sediment, perhaps from different layers of a core, place it in a drop of clean water on a microscope slide, stir with a toothpick, put a coverslip on, and look at it under the microscope. The kids may see protozoa and other tiny animals, or algae, especially in sediment from the very surface of the mud or sand. Certainly they will see the different sorts of particles which make up pond bottom deposits — mineral particles of various sizes and shapes, and particles of organic material which have come from decaying plant and animal material.

Incidentally, you and your students may have already found some evidence of decay — the smells produced when you stirred up bottom mud. When organic matter decays in the absence of oxygen (there is usually very little oxygen below the very surface of pond sediments), gases such as methane (marsh gas) and hydrogen sulfide (rotten egg gas) are produced.

If the kids have found snails in the pond, brightly colored nail polish or enamel paint can be used to mark the animals. Just dry part of the shell, put a small spot of polish on, and give it a couple of minutes to dry before returning the snail to the pond. By using different colors or numbers of dots on each snail, the movements of individual snails can be followed. Be sure to record the exact location where the snails are caught each time.

Your class may have noticed some difficulty in seeing the pond bottom due to surface glare. If so, why not make yourself an underwater viewer! Get a piece of large diameter plastic pipe, plastic bucket, stovepipe, or a large tin can with the ends cut out and cover one end of this cylinder with

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Not surprisingly, scientists have come up with names for all the possible sub-habitats and for the different groups of organisms which are found in these habitats. An additional complication is that the open water zone where rooted aquatic plants are growing is often called the *littoral zone*. Thus, a pond whose bottom is completely covered by plants has no limnetic zone at all!

Habitat	Name of the Zone	Name Used for Microscopic Organisms	Name used for Macroscopic organisms
Open Water	Limnetic	Plankton includes animals —zoo-plankton, and plants — phytoplankton	Nekton — animals swimming in water e.g. fish; Neuston-animals living in surface film
Open Water with Rooted Plants	Littoral	As above	As above
Bottom Sediment (Mud, Sand)	Benthic	Microbenthos— includes zoomicro- and phytomicro-benthos	Macrobenthos— includes only animals e.g. insect larvae, snails; Macrophytes-rooted plants
Stems and Leaves of Plants	No particular name	Periphyton— includes both algae and small animals	No particular name

plastic wrap, a plastic bag, or glass held in place with an elastic band or glue, and you have your viewer. This is a particularly useful piece of equipment if you have a small boat or inflatable raft and want to look at the pond bottom away from the shore. Incidentally, your view beneath the pond surface can be improved just by putting on a pair of polarizing sunglasses, which cut out much of the surface glare.

If temperatures are warm enough, another way to observe underwater life is to float quietly on an air mattress and use a face mask and snorkel. The kids might also want to construct an observation platform over the pond.

Language Arts at the Pond

Looking so closely at the pond and its inhabitants can provide inspiration for some creative writing! Suggest that your students try to write short poems about the pond, and their reactions to what they see or feel at the pond. Two forms of poetry which are fun to write are the Japanese "haiku" form, and "cinquain" poetry.They are particularly suitable for outdoor experiences.

A haiku poem expresses a complete feeling or mood in just three lines of 5, 7, and 5 syllables. For example:

Water shimmering,
In the sun's steady hot stare.
Pond lilies smile back.

Cinquain poetry has five lines, the first being only one word, a noun, the second line has two words, often describing the noun; the third line has three action words; the fourth has four words; the fifth line is one word again, a noun which refers back to the first noun. For example:

Leaf:
Green, veined;
Waving gently, silently;
Making its own way;
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How Organisms Get to the Pond

Now that you are investigating what lives in the pond, and where in the pond the organisms live, it is probably inevitable that someone will wonder how the different plants and animals got to the pond in the first place. This is a good question for discussion and some experimentation. How, for example, did the plants arrive at the pond? "Seeds" will be immediately suggested, but how did the seeds get to the pond? Did they blow in on the wind, or float down a stream from some other pond, were they carried in some bird's digestive tract, or did they hitchhike in the mud on a bird's feet or feathers?

It is easy to see how flying insects could lay their eggs in the pond, and how frogs could hop from pond to pond, but where did all the microscopic animals (and plants) come from? To see if these organisms too, could have "blown in", you can do an experiment. Hopefully one of your pupils will suggest an experiment like this. Filter a quantity of pond water through a handkerchief and boil it to remove or kill any small organisms already in the water. After cooling the water, place it in several clean, wide-mouthed jars and leave them uncovered around the perimeter of the pond. Take a small sample of the water every week or two and look at it under a microscope. Note any microscopic organisms that begin to grow. You may also be lucky and some pregnant mosquito or other insect will take a liking to your "mini-ponds" and lay her eggs!

If your pond is continually receiving tiny seeds, spores, eggs, and resting stages, it probably is sending out some of its own. To investigate this, you might use the jars full of boiled water again, but this time set the uncovered jars out in line at different distances from the pond. You can put this line of jars downwind or put several lines of jars out in different directions from the pond. Check the jars every week, and see if the jars closest to the pond develop populations of microorganisms before the other jars do.

Culturing in the Classroom

Your class will probably want to bring some pond water and organisms back to the classroom. This is fine, but try to

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Many microscopic aquatic plants and animals have "resting stages" which are capable of surviving dry conditions. This is especially true of the algae and the unicellular animals (protozoans) but rotifers, microcrustaceans and some insects also have resting stages or resting eggs. These resting stages are produced when the plants or animals are stranded in a pond or part of a pond which is gradually drying up and the resting stages enable these organisms to survive the dry season. This is how temporary ponds become repopulated so quickly when it rains — many plants and animals just come out of dormancy! Larger animals such as frogs may just burrow into the mud and survive dry conditions in this way. An interesting activity is to take a little of the mud from along the pond's edge back to the classroom, add some water, and observe over a week or two — you will be surprised at the tiny organisms which miraculously appear!

While they are in this dried out state, the microscopic plants and animals weigh no more than a dust particle and are easily picked up and carried by the wind to another body of water. It is thought that this type of wind transport along with "hitchhiking" on birds accounts for the rapid colonization of new puddles and ponds.

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take only the animals you wish to study, and return them to the pond when the study is finished. One interesting activity is to put a small amount of water in small plastic bags and attach them to the bulletin board with staples or pins (at the top of the bag!). The plastic allows the passage of oxygen and carbon dioxide, and these "mini-aquariums" will stay healthy for two weeks or more. Otherwise, jars or a regular aquarium can be used.

Be sure to keep the temperature of the aquarium from getting too high. If the kids have chosen to keep records of the pond temperature, then this is a good time to have a discussion about how temperature influences the organisms living in the pond. All pond animals are "cold-blooded" and depend on their environment for enough heat to move. The class may have noticed that pond animals (e.g. insects) move more slowly on cool days than on warm days. They can experiment with this phenomenon in the classroom. For instance, they might observe an insect's behavior in a jar of water. Cool, or warm the pond water by placing the jar in a dishpan of cold or hot tap water, and observe the animal's behavior. Use the microscopes to check the tiny animals too.

If you want to keep a small pond aquarium cool, or perhaps have two aquaria and compare a cool one and one kept at room temperature, it is easy to set up a cooling system using flexible plastic tubing, such as aquarium air tubing. Simply connect one end of the tubing to a cold water tap, make several coils of tubing inside the aquarium, and run the other end out to a sink. By continuously running a trickle of cold tap water through the tubing, you will keep the aquarium cool.

Studying Pond Temperatures

Does the pond change temperature during the day? If possible, measure the pond's temperature several times during a sunny day and at night, and make a graph showing the temperature fluctuations. Is there any difference between the temperature of the air, the temperature at the surface of the pond, at a point halfway to the bottom, and at the bottom? If you have a deep pond and can't reach halfway to the bottom, make a water sampling bottle from an old plastic bleach bottle, a cork, a rock, and some string. Carefully lower the weighted bottle to the desired depth (mark the line off in metres) and pull the cork. Depending on the depth, it may be a little difficult to remove the cork which is held in by water pressure. Then you can haul the bottle to the surface and stick a thermometer in the neck or pour some water into another container and quickly measure the temperature.

Try to relate temperature differences at the different points in the pond to the location of particular pond animals. Do any animals appear do have temperature preferences? What effect do you think low temperatures have on the growth of pond plants?

How Pond Animals Get their Food

There are countless things your kids can observe and investigate using a pond aquarium in the classroom. They can compare the ways in which different kinds of animals feed, e.g. predatory dragonfly larvae catching prey, herbivorous snails eating vegetation, tiny *Daphnia* filtering the water for small algae particles, etc. With the larger animals, your class can experiment to determine food preferences (plant or animal food, live or dead food) and the amounts of food eaten. Do the predatory animals hunt for their prey or sit still and wait for the prey to come by?

Watch how a frog catches a fly. How far does his tongue reach? How fast does it move? See how fast the kids can stick their tongues out, bring them back, and close their mouths!

To make the filter feeding of small crustaceans like *Daphnia* more obvious, you can add material such as India ink* to the water. The *Daphnia* will fill their digestive tracts with the ink particles and the almost transparent animals can then be observed with a microscope.

Once your students have started to investigate the feeding habits of the pond animals, an interesting exercise

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take only the animals you wish to study, and return them to the pond when the study is finished. One interesting activity is to put a small amount of water in small plastic bags and attach them to the bulletin board with staples or pins (at the top of the bag!). The plastic allows the passage of oxygen and carbon dioxide, and these "mini-aquariums" will stay healthy for two weeks or more. Otherwise, jars or a regular aquarium can be used.

Be sure to keep the temperature of the aquarium from getting too high. If the kids have chosen to keep records of the pond temperature, then this is a good time to have a discussion about how temperature influences the organisms living in the pond. All pond animals are "cold-blooded" and depend on their environment for enough heat to move. The class may have noticed that pond animals (e.g. insects) move more slowly on cool days than on warm days. They can experiment with this phenomenon in the classroom. For instance, they might observe an insect's behavior in a jar of water. Cool, or warm the pond water by placing the jar in a dishpan of cold or hot tap water, and observe the animal's behavior. Use the microscopes to check the tiny animals too.

If you want to keep a small pond aquarium cool, or perhaps have two aquaria and compare a cool one and one kept at room temperature, it is easy to set up a cooling system using flexible plastic tubing, such as aquarium air tubing. Simply connect one end of the tubing to a cold water tap, make several coils of tubing inside the aquarium, and run the other end out to a sink. By continuously running a trickle of cold tap water through the tubing, you will keep the aquarium cool.

Studying Pond Temperatures

Does the pond change temperature during the day? If possible, measure the pond's temperature several times during a sunny day and at night, and make a graph showing the temperature fluctuations. Is there any difference between the temperature of the air, the temperature at the surface of the pond, at a point halfway to the bottom, and at the bottom? If you have a deep pond and can't reach halfway to the bottom, make a water sampling bottle from an old plastic bleach bottle, a cork, a rock, and some string. Carefully lower the weighted bottle to the desired depth (mark the line off in metres) and pull the cork. Depending on the depth, it may be a little difficult to remove the cork which is held in by water pressure. Then you can haul the bottle to the surface and stick a thermometer in the neck or pour some water into another container and quickly measure the temperature.

Try to relate temperature differences at the different points in the pond to the location of particular pond animals. Do any animals appear do have temperature preferences? What effect do you think low temperatures have on the growth of pond plants?

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is to try to construct a **food web**. Write down all the plants and animals you have seen in the pond, big and small, and draw arrows between organisms according to who you think eats what. When this has been done, someone will probably notice that the plants, both big and small, are eaten by animals but that the plants themselves don't eat anybody else. And this observation is an excellent way to get into a discussion about where plants get their food. The kids will probably quickly mention sunlight, water, soil. These are fairly difficult concepts (capture of the sun's energy by plants, and passage of this energy up and through a food web) and if the students approach them in this way, they are more likely to understand and remember them.

At this point, you might like to suggest that they write a one or two page story about "A Dragonfly's Day", "The Tadpole's Miraculous Escape", "The Strangest Pond Animal", etc. Once again if possible, have the class do the writing at the pond.

There are many other activities you and your class can carry out using pond organisms. Collect frog or snail eggs, and watch their development until they hatch. Or collect tadpoles and feed them bits of vegetation until they metamorphose into air breathing frogs which only eat live insects. Record how many days it takes for the complete metamorphosis. Try to collect insect larvae and keep them alive and well until they emerge as winged adults. How many times do they molt their exoskeletons?

Look closely at the structure of rooted aquatic plants. How do they get their water? Notice that the stems, although sometimes fairly thick, are not very strong and in most cases, could not hold the plant up if it were out of water. If you bring some of these plants back to the classroom, be sure to plant them carefully in the aquarium, and observe them frequently to see how fast they grow. Do aquatic plants develop flowers?

If you are fortunate enough to have caddisfly larvae living in your pond, bring some back to the classroom and gently evict one of the larvae from its tube case by pushing it out with the wooden end of a matchstick. You can then watch it climb back into its home or better yet, construct a new one. Provide the larva with the appropriate raw materials, sand grains, pieces of twig, or whatever your particular species uses to build its case.

The caddisfly presents a good example of protective coloration due to the case it builds rather than the animal's color itself. Ask the kids what other pond animals are hard to see, and what color one should be to avoid being seen in or around a pond. The class can do an experiment to check their ideas by coloring pebbles, toothpicks, clothespins, etc. different colors, and having the teacher scatter a known number of these items around and in the pond. On the next visit, have everybody search for the colored "prey" and determine what percentage of each color is found.

How Pond Animals Move and Breathe

Your class can investigate the interesting properties of the surface tension of water and the importance of this surface tension to aquatic animals. Take some pond water; can you float a needle on it? Observe the way a water strider uses surface tension. Add a little soap to the water and see if the surface dwelling insects behave differently (soap reduces surface tension).

FOR YOUR INFORMATION

If you look closely at a mayfly larva, you can see the paddle-like gills along both sides of the abdomen waving back and forth. Other insects (e.g. midge larvae) also obtain their oxygen directly from the water, but are so small that they don't require specialized gills. Some insect larvae such as mosquito larvae live completely underwater, but obtain their oxygen through a breathing tube which is poked through the surface film to the air. And all the adult aquatic true bugs and beetles (this includes water boatmen, backswimmers, diving beetles and bugs, etc.) are air breathers which carry a small bubble of air with them when they swim underwater.

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While you have the water strider, compare its methods of locomotion (i.e. "skating" on the surface film) to the methods employed by crawling insects and insects which swim and dive. How are the insects' legs and bodies specialized for their particular way of locomotion? (e.g. the hind legs of the water boatman are flattened for swimming). How do the tiny animals which you can see through the microscope propel themselves through the water?

How do the pond animals breathe? Time an insect or other animal to see how long it can "hold its breath". Do some of them never come to the surface? Everybody knows that fish have gills but did you know that tadpoles and some insects do too?

Around the Pond

Up to now, your class has been concentrating on things that live in the pond itself. But what about the plants which are growing around and near the pond? Notice that the terrestrial plants nearest the pond are usually species of grasses or sedges. A little further back from the pond we find taller shrub-like plants, and if trees are present in the area, they will usually be found further back than the shrubs. This pattern is just a continuation on land of the pond succession discussed earlier. In a few more years, the pond will be slightly smaller and the terrestrial plants will have moved in a little bit.

Because it is a source of water and sometimes of food, the pond serves as a focal point for the terrestrial animals of the neighborhood (insects, birds, mammals). You and your class will see a number of these animals when you visit the pond, but most of the smallest mammals (mice, voles, shrews) will probably keep out of sight. To find out if any of these creatures (or birds) use the pond, you can look for tracks. Smooth out some mud on the shore with a ruler and check it for tracks on the next visit. If you find any tracks, you can make casts with plaster of Paris. How many different individuals made the tracks? How many different kinds of animal tracks do you see?

*See the unit *A Mouse by any Other Name,* by David Williams, Western Education Development Group, 1973.

Another method to detect small mammals is to put out a bit of grain, peanut butter, or fruit and check it later for evidence of someone eating. We can't guarantee that a slug or some insect won't be the culprit however! Probably the best method to detect small mammals using the pond is to use live traps.*

An interesting variation on the regular field trip is to make a visit to the pond on a spring or fall evening. Bring a fairly powerful lantern and an old white sheet. After dark, hang the sheet and shine the light on it. You will be rewarded with many different types of insects, including the adults of some of the species whose larvae inhabit the pond. The lantern can also be used to attract zooplankton in the pond itself. While visiting the pond at night, be sure to listen for all the different sounds you can hear, and compare them with daytime sounds. And don't be afraid to visit the pond when it's raining or during the winter when ice covers the water. Many animals are active during the rain or under the ice and moreover, since rain and ice are part of the pond's life, the kids should see the pond at these times too.

Bringing it Together with Photography

One activity that is a lot of fun is to put together a photo album of pond pictures. The easiest way to do this is with a Polaroid camera. Divide the kids into groups of 2-3, and give each group one exposure. Emphasize to the kids that they should give some consideration to what they want in their pictures, and should plan the composition. Let the kids operate the camera themselves. The one disadvantage of Polaroid cameras is that only the more expensive models have lenses suitable for close-up shots, e.g. of an insect larva.

A more ambitious but very valuable project is to have the class make a slide show about "A Day in the Life of the Pond" or some similar theme. For this, an Instamatic type camera is adequate, but a 35 mm camera which can take close-up pictures is ideal* *(an adult may have to operate this type of camera). If you wish to be more ambitious, you can add sound to your slide show. A simple portable cassette

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recorder will capture many pond sounds. Music can also be added.

Is the Pond Polluted?

It is unfortunate that this is one of the questions that kids are likely to ask — unfortunate because pollution is so much a fact of life today, and therefore kids have it on their minds. All natural waters contain dissolved chemicals and some of these dissolved substances are absolutely necessary for the tiny and the large plants which live in the water. The chemicals are part of the plants' food. To demonstrate their presence, just place a few drops of pond water on a clean slide (what color is the water?) and allow the water to evaporate. You will notice that what remains is a small deposit of white or brown material. This deposit is made up of the materials which were dissolved or suspended in the water. Follow the same procedure using tap water and distilled water. Is there any difference?

A way to demonstrate the presence of the tiny particles of suspended material is to shine a light through a sample of the water. Get a glass container with flat sides (e.g. a small aquarium) and fill it with pond water which you have poured through a plankton net to remove the plankton and big pieces of debris. Turn off the lights in the room and shine a flashlight through the aquarium. Can you see the tiny particles in the light path? Fill another container with tap water and compare.

FOR YOUR INFORMATION

Most ponds are not polluted in the sense that they contain toxic substances, but many ponds are quite nutrient rich, i.e. the water contains high concentrations of some dissolved chemicals. These chemicals are perfectly natural and their abundance in most ponds has nothing to do with man's activity. Exceptions include ponds draining farmyards. Pond water is usually safe to swim in and also to drink, but drinking it is not recommended simply because of the high concentration of these chemicals. Upset stomachs can easily be caused by drinking water which one is not used to, even though it contains nothing really harmful.

Another unfortunate thing about the publicity given to water pollution is that many teachers feel no pond, lake, or stream study should be undertaken without also doing "water quality tests" as part of the project. These tests often require the purchase of fairly expensive kits, some of which contain quite hazardous chemicals. Even when the chemistry of the test is understood by the teacher, it seldom is understood by elementary age students, and in any case many of the tests are extremely unreliable. In short, it is best to stay away from kits, and from equipment more sophisticated than a thermometer.

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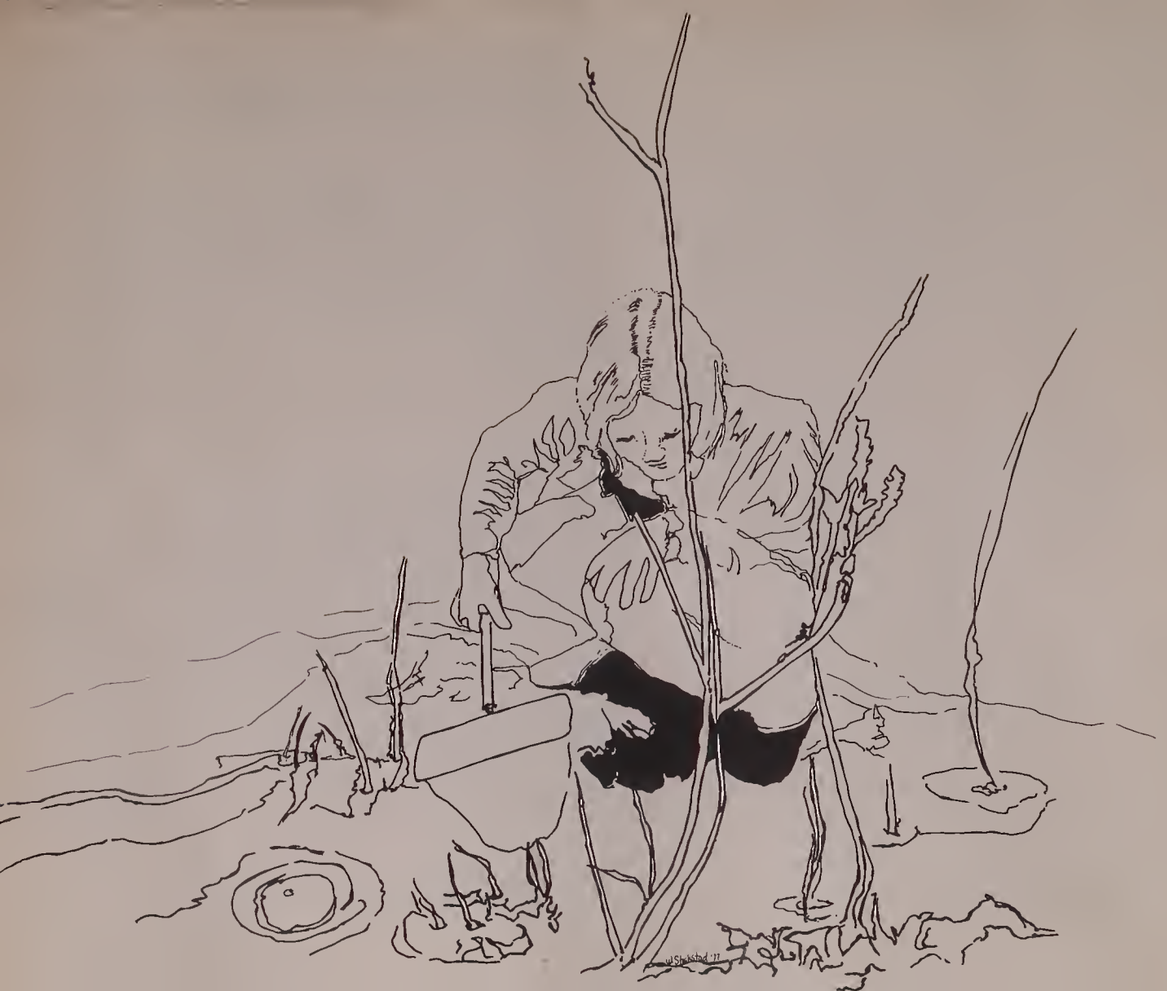

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- *How to Know the Freshwater Algae.* by G.W. Prescott.
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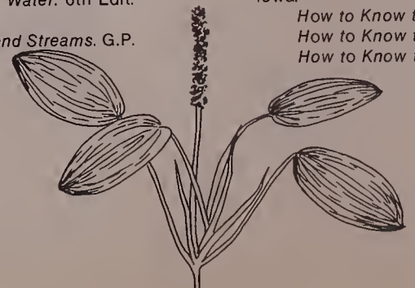

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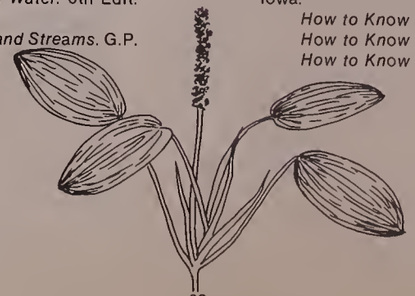
A Field Guide to Western Birds. by R.T. Peterson.

Pictured—Key Nature Series. Wm. Brown Co., Dubuque, Iowa.

How to Know the Freshwater Algae. by G.W. Prescott.

How to Know the Insects. by H.E. Jacques.

How to Know the Immature Insects. by C. Hung-Fu.



Credits

The Pond Book was written by Michael Hoebel, a teacher in Richmond School District, Richmond, British Columbia. The unit is an outgrowth of work which was begun by Tom Purakal. Others who have contributed to the development of the unit include Pat Woolsey, Cathy Henry and Kip Anastasiou.

We would like to thank Mr. Neil Dyck and his students at Carnarvon Elementary School for their help in the original trials.

Many of our staff members contributed to the photography, typing and proofreading. They include: Oksana Galichenko, Cindy Barrett, Karen Ward, Donna MacGregor, Linda Seaton, Patrisha Gildersleeve, and Karen Anastasiou.

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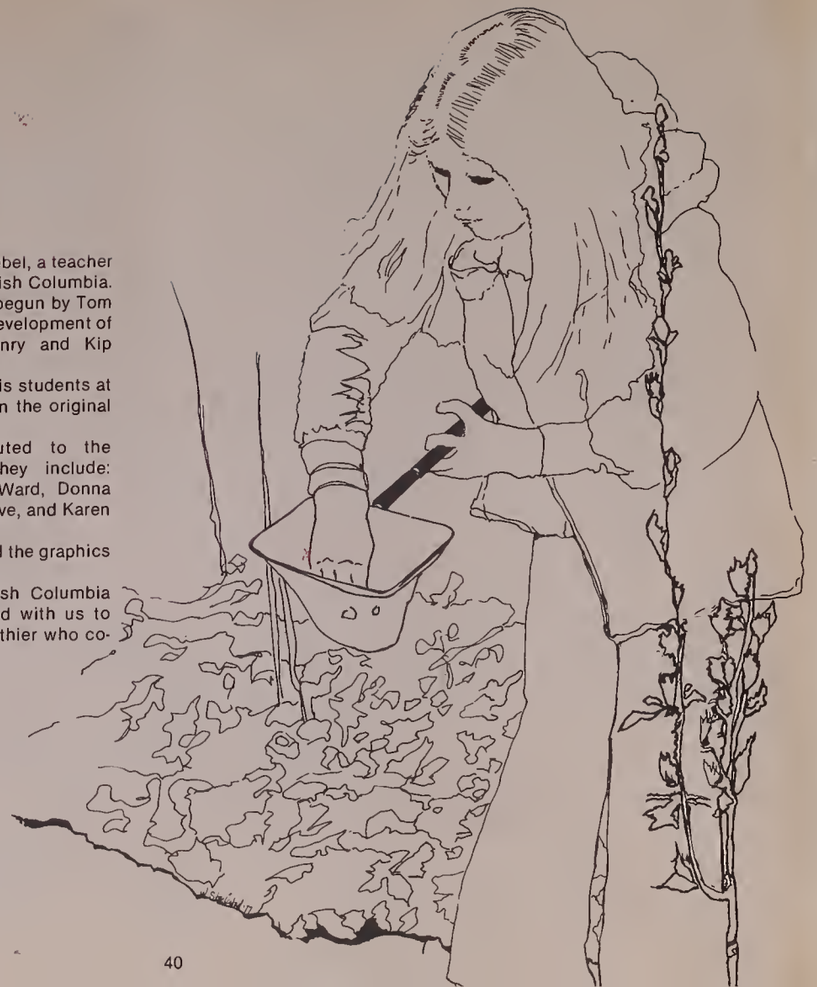

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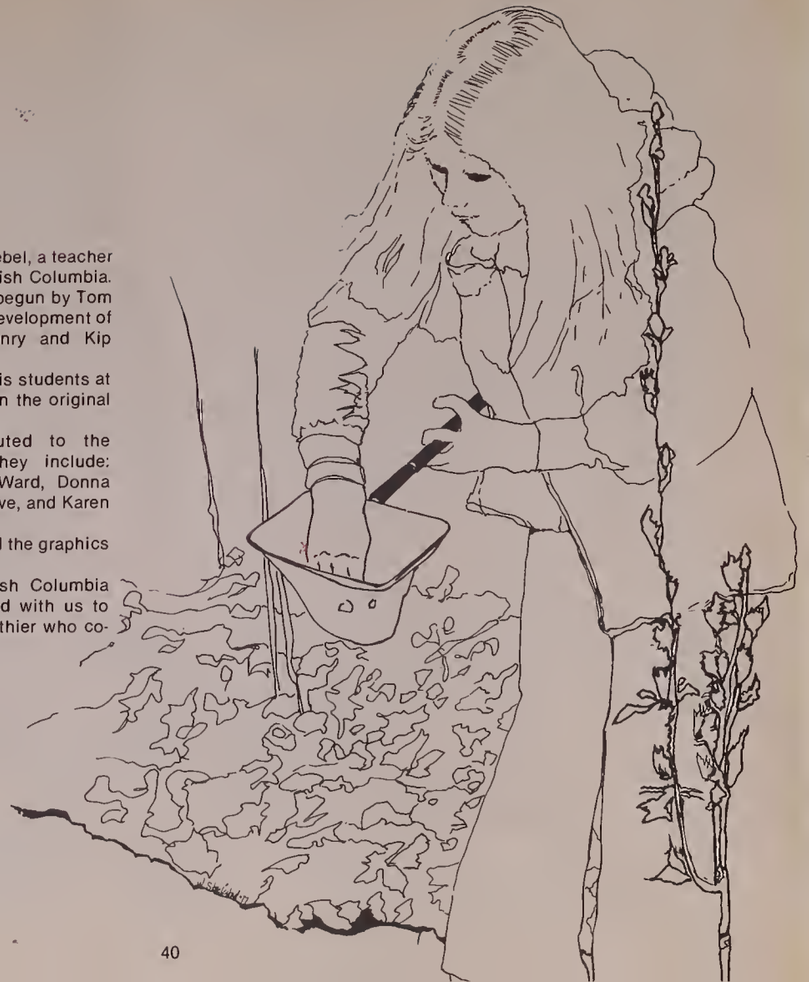

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